IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of:
John G. DeSteese and Larry C. Olsen
Application No. 10/727,062
Filed: December 2, 2003
Confirmation No. 4870
For: THERMOELECTRIC POWER SOURCE UTILIZING AMBIENT ENERGY HARVESTING FOR REMOTE SENSING AND TRANSMITTING
Examiner: Jeffrey Thomas Barton
Art Unit: 1795
Attorney Reference No. 23-69853-01

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COMMISSIONER FOR PATENTS

DECLARATION OF JOHN DESTEESE UNDER 37 CFR § 1.132

JOHN G. DESTEESE, being duly sworn does hereby declare and affirm the following:

That he received a Bachelor of Science degree in Electrical Engineering from the University of London in 1960; that he has over 48 years' experience in analysis and development of power delivery systems that extract, convert, transport or store energy.

That he is a co-inventor of the invention claimed in Application No. 10/727,062 and that he is employed by Battelle Memorial Institute, the Assignee of Application No. 10/727,062.

That he was employed as a Senior Development Engineer in the aerospace industry at both TRW, Incorporated from 1964 to 1966 and McDonnell Douglas Corporation from 1966 to 1973; that he previously worked as a Research Engineer in the electric power industry at Westinghouse Electric Corporation, from 1961 to 1964; that he contributed to the development of thermoelectric generators and other direct energy conversion devices for each of these prior employers.

That he currently is a Staff Engineer and has been employed by Battelle Memorial Institute since 1973; that his professional experience covers a broad range and includes advanced energy conversion research and development; innovation and analysis of system concepts, and planning, integration and management of system development programs; that his research specialties currently include the capture of heat and other forms of ambient energy and their conversion into electrical power and that he continues to lead Battelle Memorial Institute research to further improve the developed thermoelectric power sources and methods.

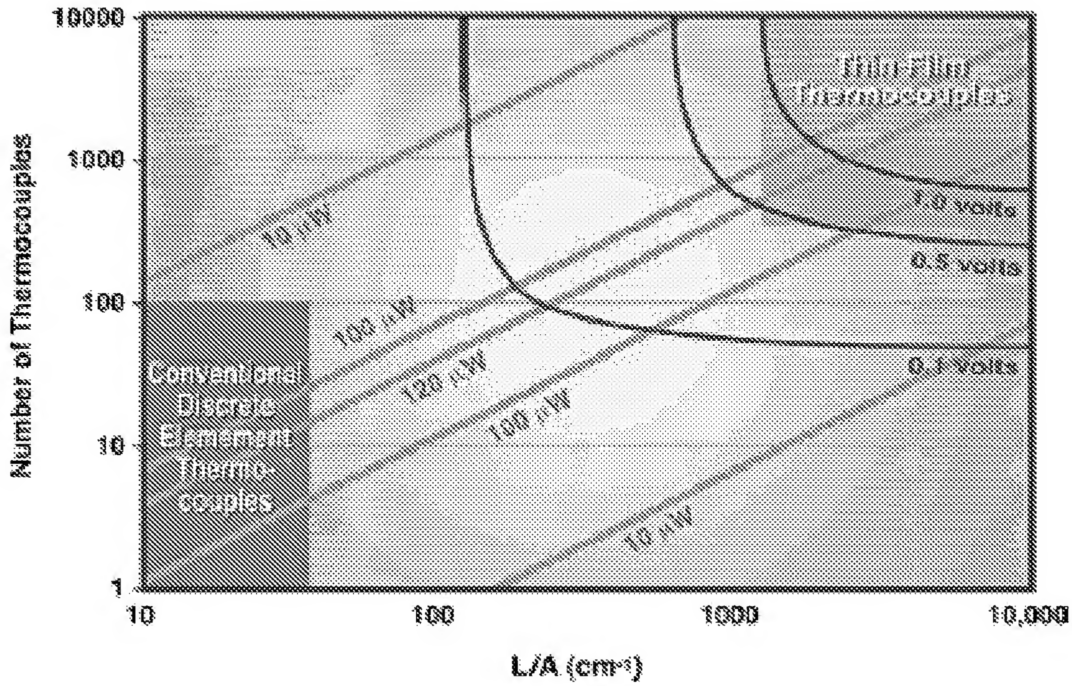
That he has read the Examiner's rejections in regard to the pending claims in Application No. 10/727,062 in the Office action dated December 31, 2008, the Migowski and Bass references cited therein.

That he actively participated in the conception, research and development of the thermoelectric power sources and methods as disclosed in this and related applications. That he actively participated in studies and testing leading to the unexpected discovery that the L/A ratio is a variable with significant (critical) effect on the resulting power of the device (and methods using such device). That specifically, this unexpected discovery revealed that the power and voltage of devices can be expressed uniquely as contours on a graph having the number of elements as its ordinate (y-axis) and L/A of the constituent thermoelements as the abscissa (x-axis) and depending upon the L/A ratio used, it provided design guidance for achieving previously unexpectedly high voltage and power output. That with such testing and discovery, the Applicants identified preferred and critical design regimes based on thermoelement L/A ratios as illustrated in the figure below, where output voltage contours and iso-power lines are shown on a chart of thermocouple number versus L/A ratios.

That, for a given difference in source and sink temperature, he achieved unexpected results when varying the L/A ratios to define preferred design configurations. That through testing and analysis he discovered the following: that L/A ratios are variables critical to achieving the desired power performance of thin-film, multi-element thermoelectric generators; that particular L/A ratios are critical to achieve the Applicants' device desired output power; that the width of the deposited thermoelectric film and the film thickness determine the area of each

thermoelement and are, in turn, important design parameters that control the internal resistance, output voltage and power of an multi-element assembly; that the voltage of a TE generator is governed by the number of thermocouples, differences in temperature that can be employed and the Seebeck coefficient (i.e. the voltage output per unit of temperature capability) of all of the thermoelements in an assembly; that the electrical and thermal conductivity of thermoelements and thermoelement shape determine the internal electrical and thermal resistance of the generator That the L/A ratio is a critical variable for achieving a desired electrical resistance of an assembly so that a useful electrical output current results when voltage is generated in the TE assembly, and that the L/A ratio controls the amount of heat that is transmitted through the TE assembly from the hot to the cold side.

That each plot as shown in the figure below as based on temperature difference, available thermal energy and intrinsic material properties will define a preferred and critical design region in which the L/A ratio of thin-film deposits is much higher than can be achieved with discrete, self-supporting thermoelements. That for given conditions, L/A ratios higher than the upper limit of the presently claimed range (10,000 cm^{-1}) produce lower power devices because implicitly higher internal resistance of the TE generator limits output. For example, the 11-microwatt thermogenerator for a watch disclosed by Migowski has thermoelements with an L/A of 15,000 cm^{-1} which is off scale beyond the upper range of the figure and claimed L/A ratios. That an L/A ratio as high as Migowski discloses limits output power to between 10 and 20 microwatts in the configuration of his device and the environment in which it is designed to operate.



That the L/A ratio is a critical aspect in the design of the disclosed and claimed thermoelectric power source that includes multiple p-type and n-type thermoelements. That through his research and analysis he discovered that an L/A ratio greater than several hundred (500 cm^{-1} for example) is critical for Applicants' preferred low-power applications – to which power applications the disclosed thermoelectric devices and methods are aimed. That once the Applicants discovered that varying the L/A ratios produced unexpectedly high power output devices, they carefully evaluated different L/A ratios to achieve a device and methods using such devices having useful voltage directly without need for further amplification and an electrical impedance match with the electrical circuit of the application (e.g., a sensor and/or transmitter) in a relatively small power source device. That the unexpectedly superior results in the developed thermoelectric devices and methods as claimed produce a thermoelectric generator that can be treated similar to a "plug-in" battery with a comparable voltage, thereby eliminating the need for voltage amplification components and their inherent power consumption.

That the following table illustrates a comparison of the present invention with the Migowski disclosure. That for the purposes of comparison the temperature difference is made

the same although the highest powered of the Applicants' devices (Example 1) is designed to produce about 510 microwatts with about a 20°C-temperature difference.

Device Parameters	Embodiment of Applicants' Disclosed Device Example 1	Embodiment of Applicants' Disclosed Device Example 2	Embodiment of Applicants' Disclosed Device Example 3	Migowski Disclosure
Thermoelement width (cm)	0.4	0.2	0.1	0.01
Thermoelement L/A (cm^{-1})	781	3125	10,000	15,000
Temperature difference (°C)	6	6	6	6
Output voltage (V)	3.0	3.0	3.0	1.6
Power (μW)	153	98	30	11

That the table above illustrates that varying L/A ratios in consideration of material properties and other design requirements produces Applicants' disclosed device with as high as over ten times the output of the Migowski disclosed device when exposed to similar environmental conditions. That the examples provided in the table essentially cover the claimed L/A ratio range of from 500 to 10,000 cm-1 and that the devices and methods of the present invention provide higher voltage and power output than achieved by the Migowski device.

The undersigned declares that all statements made herein of his knowledge are true and that all statements made on information and belief are believed to be true and further, that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment under Section 1001 of Title 18 of the United States Code, and that any such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Executed at the place and date opposite the signature below.

John G. DeSteese
John G. DeSteese

At Richland, Washington
(City and State)
on this 6th day of May, 2009.